The Tracking of Nutrient Intake in Young Children: The Framingham Children's Study

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ABSTRACT

Objectives. This study compared the nutrient intake of children at 3 through 4 years of age with that in subsequent years to determine whether nutrient intake tracked over time.

Methods. Intakes of 10 nutrients were estimated by means of multiple days of food diaries collected over a span of up to 6 years of follow-up for 95 children in the Framingham Children's Study. All diaries collected during each of three age periods (age 3 through 4, age 5 through 6, and age 7 through 8) were averaged. Nutrient density intakes at each age period were compared.

Results. Nutrient-specific correlations ranged from .37 to .63 between nutrient density intakes at age 3–4 and age 5–6. Correlations between intakes at age 3–4 and age 7–8 ranged from .35 to .62. Consistency of classification was strong; 35.7% to 57.1% of children in the highest quintile of intake at age 3–4 remained in that quintile at age 5–6, and 57.1% to 85.7% remained in the top two quintiles. At age 7–8, 40.0% to 66.7% of those with the highest intake at baseline were still in the top quintile, and 60.0% to 93.3% remained in the top two quintiles. Results were similar in the lowest quintile of intake. Extreme misclassification was rare.

Conclusions. This study suggests that tracking of nutrient intake begins as young as 3–4 years of age. (*Am J Public Health.* 1995;85:1673–1677)

Introduction

There is evidence that physiologic risk factors for cardiovascular disease—including blood pressure, cholesterol, and obesity—track from childhood to adulthood (i.e., values for a given parameter at one age are consistent with those found for subsequent ages).[1,2] Patterns of dietary intake and other health-related behaviors affect such risk factors,[1,3] and it has been proposed that most health-compromising adult behaviors have their origin in childhood.[4] This suggests that the development of healthy dietary patterns during childhood may be particularly important in the prevention of adult cardiovascular disease.

There are limited data on the tracking of the intake of foods or nutrients during childhood. Kelder et al. examined the tracking of food choices over a 6-year period beginning in the sixth grade.[5] They found that there was a tendency for those children selecting a larger number of healthy food choices in the sixth grade to select a larger number of such food choices in subsequent years; nutrient intakes were not assessed. Stein et al. studied tracking of nutrients in preschool children over an average of 19 months; they reported Pearson correlation coefficients for energy-adjusted intakes of nine nutrients ranging from .12 (for polyunsaturated fat) to .59 (for calcium).[6] Between 20% and 50% of their children in the highest quintile of the energy-adjusted intake of a nutrient at baseline remained in the highest quintile of intake of that nutrient at follow-up. The tracking of non-energy-adjusted intakes was somewhat better.

We used multiple days of food diaries each year to assess nutrient intakes of young children in the Framingham Children's Study beginning in 1987. This paper describes the tracking of the intakes of 10 nutrients over a 6-year period, starting when the children were 3 through 4 years of age.

Methods

The Framingham Children's Study is a longitudinal study of factors related to the development of dietary habits and physical activity patterns during childhood. In 1987, 106 two-parent families were enrolled into the study. These families were third- and fourth-generation offspring of subjects in the Framingham Heart Study who lived within approximately 40 miles (64 km) of Framingham, Mass, and had a healthy biologic child between the ages of 3 and 5 years.

Diet has been assessed each year by means of multiple sets of 3-day food diaries. At the initial clinic visit, each family was instructed by the study nutritionist in the completion of food diaries, including use of common household measures to estimate portion sizes. Completed food diaries were reviewed by the study nutritionist, and additional debriefing was done by telephone if needed. Because of the ages of the children at enrollment, the parents completed all food diaries for the first 4 years. For those children in day care or preschool, supplemental food diary information was col-

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TABLE 1—Mean (±SD) Nutrient and Nutrient Density Intake in 95 Children: The Framingham Children's Study

	Age 3–4 (n = 77)	Age 5–6 (n = 86)	Age 7–8 (n = 91)
Total energy	1528 ± 253	1677 ± 264	1876 ± 297
Protein, g	52.8 ± 11.2	58.2 ± 11.4	64.5 ± 12.7
Energy from protein, %	13.8 ± 2.0	13.9 ± 1.7	13.8 ± 1.7
Carbohydrate, g	209.3 ± 39.5	226.4 ± 41.6	255.8 ± 44.5
Energy from carbohydrate, %	54.8 ± 5.2	54.0 ± 5.1	54.7 ± 5.3
Total fat, g	56.1 ± 12.3	62.6 ± 12.9	69.0 ± 16.0
Energy from total fat, %	33.0 ± 4.3	33.6 ± 4.3	33.0 ± 4.4
Saturated fat, g	21.3 ± 6.2	24.1 ± 5.8	26.1 ± 7.6
Energy from saturated fat, %	12.4 ± 2.5	12.9 ± 2.2	12.4 ± 2.4
Monounsaturated fat, g	19.9 ± 4.5	22.9 ± 4.8	25.4 ± 5.9
Energy from monounsaturated fat, %	11.7 ± 1.7	12.3 ± 1.7	12.1 ± 1.8
Polyunsaturated fat, g	8.9 ± 2.4	10.4 ± 2.6	12.4 ± 3.0
Energy from polyunsaturated fat, %	5.3 ± 1.1	5.6 ± 1.0	5.9 ± 1.1
Cholesterol, mg	192 ± 66	189 ± 74	183 ± 74
Cholesterol, mg per 1000 kcal	125 ± 39	112 ± 37	97 ± 33
Calcium, mg	793 ± 225	868 ± 246	923 ± 261
Calcium, mg per 1000 kcal	518 ± 117	516 ± 116	490 ± 111
Potassium, mg	2069 ± 453	2111 ± 480	2241 ± 428
Potassium, mg per 1000 kcal	1354 ± 214	1256 ± 192	1201 ± 184
Sodium, mg	2014 ± 428	2242 ± 404	2622 ± 520
Sodium, mg per 1000 kcal	1322 ± 205	1345 ± 187	1398 ± 174

TABLE 2—Spearman Correlation Coefficients between Age Groups' Nutrient Density Intakes

	Coefficient (95% Confidence Interval)		
	Baseline (Age 3–4) vs Age 5–6 (n = 68)	Baseline (Age 3–4) vs Age 7–8 (n = 73)	Age 5–6 vs Age 7–8 (n = 82)
Energy from protein, %	.47 (.26, .64)	.38 (.16, .56)	.46 (.27, .62)
Energy from carbohydrate, %	.63 (.46, .76)	.57 (.39, .71)	.65 (.50, .76)
Energy from total fat, %	.61 (.43, .74)	.55 (.36, .69)	.62 (.46, .74)
Energy from saturated fat, %	.54 (.34, .69)	.42 (.21, .60)	.55 (.38, .69)
Energy from monounsaturated fat, %	.61 (.43, .74)	.62 (.45, .75)	.59 (.43, .72)
Energy from polyunsaturated fat, %	.43 (.21, .61)	.35 (.13, .54)	.48 (.29, .63)
Cholesterol, mg per 1000 kcal	.39 (.16, .58)	.42 (.21, .60)	.51 (.33, .66)
Calcium, mg per 1000 kcal	.50 (.29, .66)	.42 (.21, .60)	.59 (.43, .72)
Potassium, mg per 1000 kcal	.54 (.34, .69)	.53 (.34, .68)	.57 (.40, .70)
Sodium, mg per 1000 kcal	.37 (.14, .56)	.48 (.28, .64)	.32 (.11, .50)

lected from other caregivers. Beginning in the fifth year of the study, the children were asked to assist in the process by keeping a list of foods eaten away from home. Four sets of 3-day food diaries were requested in the first year (one set for each season); in years 2, 3, and 5, two sets were requested approximately 6 months apart, and one set was requested in years 4 and 6.

In these analyses, we examined nutrient tracking by the age of the child. To do this, we classified each set of food diaries into one of the three following age categories: age 3 through 4 (i.e., 3.0 through 4.9 years), age 5 through 6 (i.e., 5.0 through 6.9 years), or age 7 through 8 (i.e., 7.0 through 8.9 years). (These categories reflected the time of completion of the diary.) We then compared nutrient intakes at age 3–4 with those at age 5–6 and age 7–8. We included data from 95 children who provided food diaries in at least two of the three age categories to allow us to compare nutrient intake over time. The 11 children excluded from these analyses did not differ from those included with respect to race, baseline age, gender, or mother's rate of employment, although the parents of these children were slightly less well educated. We did not restrict these analyses to children with data in all three time periods since 19% of the children were greater than 4.9 years of age at the time the first food diary was completed. Children who entered the study at age 3 could provide as many as 6 years of data for these analyses, while those entering the study at age 5 could provide a maximum of 4 years of data.

The Food Finder program of Witschi et al.[7] was used in performing nutrient calculations for dietary data from the first 2 years. In the last 4 years, nutrient calculations were performed with Minnesota Nutrition Data System (Nutrition Coordinating Center, University of Minnesota) software (food database version 6A, nutrient database version 21).[8]

The nutrients examined in these analyses were protein, carbohydrate, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, calcium, sodium, and potassium. Since total intake would be expected to increase from 3 to 8 years of age, we adjusted the nutrient intakes for total energy by using nutrient density in these analyses. We expressed energy nutrients as a percentage of total energy, and we expressed cholesterol and minerals as milligrams per 1000 kcal.

Pearson and Spearman correlations were calculated between nutrient density intakes for each age group. In addition, the distribution of nutrient density intakes within each age category was divided into quintiles, and the nutrient density quintile classifications at age 3–4 were compared with those in each subsequent age period.

Results

The 95 children included in these analyses (37 girls and 58 boys) had a mean age of 4.0 years at the time the first food diary was completed. All families of those included were White, and the families were generally middle class. More than 80% of both fathers and mothers had completed high school, 44% of fathers and 37% of mothers had earned a college degree, and 50% of mothers were employed outside the home.

Of the 95 children included in these analyses, 77 were 3 or 4 years of age and

TABLE 3—Tracking of Children's Nutrient Density Intake, by Classification into Quintiles

	Highest Quintile at Initial Age			Lowest Quintile at Initial Age		
Nutrient Density and Age Group, y	Highest Quintile at Subsequent Age, %	Highest Two Quintiles at Subsequent Age, %	Lowest Quintile at Subsequent Age, %	Lowest Quintile at Subsequent Age, %	Lowest Two Quintiles at Subsequent Age, %	Highest Quintile at Subsequent Age, %
Protein						
3–4, 5–6	42.9	64.3	7.1	38.5	76.9	0.0
3–4, 7–8	46.7	66.7	0.0	50.0	71.4	0.0
5–6, 7–8	58.8	82.4	5.9	37.5	62.5	12.5
Carbohydrate						
3–4, 5–6	50.0	71.4	0.0	61.5	84.6	7.7
3–4, 7–8	66.7	73.3	0.0	50.0	71.4	0.0
5–6, 7–8	52.9	82.4	0.0	50.0	75.0	0.0
Total fat						
3–4, 5–6	57.1	85.7	0.0	46.2	84.6	0.0
3–4, 7–8	53.3	73.3	0.0	57.1	78.6	0.0
5–6, 7–8	41.2	82.4	0.0	56.3	75.0	0.0
Saturated fat						
3–4, 5–6	50.0	71.4	7.1	53.9	69.2	0.0
3–4, 7–8	46.7	73.3	0.0	42.9	64.3	7.1
5–6, 7–8	47.1	64.7	5.9	50.0	68.8	0.0
Monounsaturated fat						
3–4, 5–6	42.9	85.7	7.1	38.5	76.9	0.0
3–4, 7–8	46.7	80.0	0.0	57.1	85.7	0.0
5–6, 7–8	52.9	76.5	5.9	37.5	62.5	0.0
Polyunsaturated fat						
3–4, 5–6	50.0	78.6	7.1	46.2	61.5	0.0
3–4, 7–8	46.7	80.0	6.7	35.7	57.1	7.1
5–6, 7–8	52.9	82.4	0.0	37.5	62.5	12.5
Cholesterol						
3–4, 5–6	35.7	57.1	0.0	46.2	76.9	15.4
3–4, 7–8	40.0	60.0	13.3	64.3	78.6	0.0
5–6, 7–8	47.1	76.5	5.9	37.5	81.3	0.0
Calcium						
3–4, 5–6	35.7	64.3	7.1	38.5	69.2	0.0
3–4, 7–8	40.0	66.7	26.7	50.0	78.6	0.0
5–6, 7–8	41.2	82.4	0.0	37.5	68.8	6.3
Potassium						
3–4, 5–6	50.0	64.3	0.0	53.9	69.2	7.7
3–4, 7–8	46.7	93.3	0.0	35.7	57.1	7.1
5–6, 7–8	41.2	76.5	0.0	50.0	68.8	0.0
Sodium						
3–4, 5–6	35.7	71.4	7.1	38.5	76.9	15.4
3–4, 7–8	40.0	66.7	0.0	57.1	64.3	7.1
5–6, 7–8	41.2	58.8	17.7	43.8	62.5	18.8

Note. Data for protein, carbohydrate, and total, saturated, monounsaturated, and polyunsaturated fat were expressed as percentage contribution to total energy; other nutrients were expressed as milligrams per 1000 kcal. The expected values are 20% for exact agreement and extreme discordance and 40% for agreement within one quintile. The number of children with data at both ages 3–4 and 5–6 is 68; at both ages 3–4 and 7–8, 73; and at both ages 5–6 and 7–8, 82.

18 were 5 or 6 years of age at the time the first food diary was completed. Of the 77 children with baseline data at age 3–4, 68 also provided food diaries at age 5–6 and 73 provided diaries at age 7–8; 64 of these children provided data in all three age categories. All 18 children in the age 5–6 category at the time the first food diary was completed provided food diaries at age 7–8; thus, there were 82 children with data at both age 5–6 and age 7–8. We had data from an average of 10.7 days of food diaries for children at age 3–4, 9.6 days at age 5–6, and 7.4 days at age 7–8. The medians in terms of days of food diaries were 12, 9, and 9, respectively, for the three age categories.

Table 1 shows the mean raw nutrient and nutrient density intakes for children in each age category. As would be expected, mean energy and nutrient intakes increased with age with the exception of cholesterol, which changed little over time. The percentage of energy derived from each energy nutrient remained quite stable; nutrient density intakes for calcium remained fairly stable, but sodium increased slightly and potassium and cholesterol decreased.

Correlation Analyses

Results of Pearson and Spearman correlation analyses were very similar, but only Spearman correlations are presented because we were interested in the persistence of the child's relative ranking of nutrient intake from year to year. Since the correlations of raw nutrient intakes were very similar to those for nutrient density values and since nutrient density values adjusted for the child's increasing intake with age, only the correlations of nutrient density intakes are presented.

Spearman correlations between nutrient density intakes at age 3–4 and at age 5–6 ranged from .37 to .63, with correlation coefficients for 6 of 10 nutrient density intakes being .5 or greater (Table 2). The highest correlations were for percentage of energy from carbohydrate (.63) and percentage of energy from total fat and monounsaturated fat (.61 for both). The lowest correlations were for sodium (.37) and cholesterol (.39). Correlations between baseline data (age 3–4) and data at age 7–8 were only slightly lower, ranging from .35 to .62. Finally, we examined the correlations between intake at age 5–6 and that at age 7–8. In general, these correlations were similar and, for a few nutrients, somewhat stronger than those based on intake at age 3–4.

Tracking by Baseline Classification

Table 3 shows the proportion of children in the highest and lowest quintiles of nutrient density intake at baseline who remained in those same quintiles or moved only one quintile in subsequent years. Of the children in the highest quintile of intake at age 3–4 for each nutrient, 35.7% to 57.1% remained in the highest quintile and 57.1% to 85.7% remained in the highest two quintiles at age 5–6; furthermore, 40.0% to 66.7% of these children in the highest quintile at baseline remained in the highest quintile at age 7–8, and 60.0% to 93.3% remained in the highest two quintiles. Of the children in the highest quintile of intake at age 5–6, 41.2% to 58.8% remained in the highest quintile and 58.8% to 82.4% remained in the highest two quintiles at age 7–8. The proportion of children remaining in the lowest quintile and the lowest two quintiles was similar for each pair of ages. Extreme misclassification was rare. The percentages of energy intake from carbohydrate, total fat, and saturated fat were the most consistently classified across age periods. Consistency of classification for sodium, calcium, and cholesterol was lower. The percentage of energy intake from carbohydrate was greater than 58.4% in the highest quintile and less than 50.3% in the lowest quintile; the percentage of energy intake from fat was greater than 35.6% in the highest quintile and less than 29.5% in the lowest quintile.

Discussion

This study supports the idea that nutrient intakes track from preschool to the early school years. In general, the strongest correlations in intake over time were found for carbohydrate and fat, particularly total and monounsaturated fat. From a chronic disease perspective, interest is most often in individuals with extremes of intake (e.g., very high fat or very low calcium intakes). In this study, we found that children with extreme levels of intake tended to maintain those levels over time. For example, of the children in the top quintile of percentage of energy intake from fat at age 3–4, 57.1% remained in the top quintile at age 5–6 and 53.3% remained in the top quintile at age 7–8.

Stein et al. examined nutrient tracking of the preschool diet in a predominantly Hispanic, low-income population in New York City.[6] In their study, tracking correlations for unadjusted nutrient intakes (.27 to .45), as well as nutrient density intakes (.12 to .59), were lower than those we found. Differences in the populations studied may account for some of the differences in the strength of the correlations found in the two studies. For example, the use of a less well-educated, low-income population by Stein et al. could have produced greater random error in estimates. However, the nutrient density correlations that were weakest in the analyses of Stein et al. (percentage of energy from polyunsaturated fat and milligrams of cholesterol and sodium per 1000 kcal) were the same as those we saw. It is also likely that the stronger correlations that we found were related in part to the larger number of days of diet records for each age category. Although we had fewer children in our cohort, we had much more information per child, providing more stability to the estimated intake of each child.

It is particularly interesting in this study that nutrient tracking remained strong through 7–8 years of age. We expected that tracking might weaken with time, as the children consumed more foods outside the home (e.g., at school, at friends' homes). However, this was not the case. One explanation may be that the diet patterns formed in the first few years continue to have a strong influence on food choices even outside the home. Another possibility is that although children are eating away from home more often, most of their food is still consumed at or provided from home. Alternatively, the persistently strong correlations may result in part from the parents' similar reporting of the child's intake from year to year.

The three nutrients with the poorest evidence of tracking were cholesterol, sodium, and polyunsaturated fat. The poorer tracking for these nutrients may be due in part to the need for more days of diet records to more precisely estimate their intake. Nelson et al. provided estimates of the number of days required to rank dietary intakes with desired precision for seven age/gender groups in 18 published studies of British population samples.[9] In the studies of toddlers and children, the number of days of food diaries required for the nutrients evaluated in our study ranged from 4 to 28. The two nutrients requiring the highest number of days for accurate ranking among children were cholesterol (18 to 21 days) and polyunsaturated fat (18 to 28 days). Sodium was not evaluated in that paper.

A limitation of the current study is the use of two different nutrient databases for the calculation of nutrient intake data. The two nutrient calculation systems had been compared by having the study nutritionist enter 25 days of food records into each system. Overall, the two systems produced very comparable results for energy and all nutrients, with correlations ranging from .77 for cholesterol to .98 for carbohydrate. Correlations for energy and 7 of the 10 nutrients were above .85. It is likely that the use of the two systems would introduce additional random error into the estimation of nutrient intake. This would have the effect of biasing the observed tracking correlations toward the null.

A related limitation of this study is the small number of nutrients that could be examined in the analyses, since the Food Finder system provides estimates for only 10 nutrients. These include the energy-providing nutrients including saturated, monounsaturated, and polyunsaturated fat but only three minerals and no vitamins or fiber. It is conceivable that nutrients we were not able to estimate track differently from those we examined.

Another concern regarding the study is not having complete data for all children at all three age periods as a result of compliance problems. To address this concern, we examined tracking of nutrient intake in only the 64 children with data available at all three periods. The correlation coefficients were essentially unchanged from those presented, although the variability was slightly larger because of the smaller sample size. We have presented results of the analyses using all available data since the larger sample size provides increased precision to the estimates.

Our results suggest that tracking of the intake of nutrients begins as young as 3 to 4 years of age, a finding that has implications for the prevention of cardiovascular disease. For maximum effect, approaches for establishing healthy dietary practices may need to begin early in childhood. □

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